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OBSERVATIONS ON THE PONDEROSA PINE RESIN MIDGE

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OBSERVATIONS ON THE PONDEROSA PINE RESIN MIDGE

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1/ This paper includes unpublished information from the files of the Bureau of Entomology and Plant Quarantine.

The ponderosa pine resin midge (_Retinodiplosis_ sp.,2/ Cecidomyiidae) is a native insect of the pine forests of California. It attacks ponderosa pine (_Pinus ponderosa_ Laws.) and Jeffrey pine (_P. jeffreyi_ Grev. and Bal.). The latter species, however, is attacked only when near infested ponderosa pine. In both species the sapling and pole size trees are preferred. Older trees are sometimes infested, but usually only in the lower portion of the crown. Seedlings less than 3 years old apparently are immune. Injury is caused by the larvae, which feed in the phloem of the current season's shoots. This results in distortion of the infested leader and branches, and frequently in killing of the tips (Figure 1).

2/ Determined by C. T. Greene, Bureau of Entomology and Plant Quarantine.

Figure 1. Life history of the ponderosa pine resin midge, _Retinodiplosis_ sp.

Recently the resin midge has been causing serious injury in plantations of the Institute of Forest Genetics[3] at Placerville, California. The trees

[3] U. S. Forest Service, California Forest and Range Experiment Station.

in these plantations are used in an intensive study of vigor and other characters in developing superior types of trees for reforestation. The work reported in this paper was undertaken to develop a method of protecting these highly valuable trees. So little was known of the habits of the insect that it has also been necessary to include a study of the life history. The work was begun in 1939 and has continued intermittently. The results given below are preliminary in nature.

LIFE HISTORY AND HABITS.-- As shown in figure 1, the ponderosa pine resin midge was found to have one generation per year. Adults appear during the latter part of March and are present until early in May. They are small, delicate insects, approximately 3.5 mm. in length and 4.5 mm. in alar expanse. The color in both sexes is a dark gray-brown excepting the abdomen, which is crimson. The adults are fully developed when they emerge, each female containing 80 to 100 fully formed eggs. Mating begins almost immediately after emergence, and the females being ovipositing within a day or two. Length of adult life in field and laboratory cages ranged from 5 to 12 days.

It was found that daily activity of the adults takes place mostly during the afternoon hours. When there was appreciable air movement, however, or when the temperature exceeded 85 °F. or fell below 65°, the adults remained quietly hidden in the foliage of the host trees. There was no activity at night and very little in the forenoon, even though wind and temperatire conditions were favorable. This species is evidently not a strong flier, even under favorable conditions, for the annual spread of the infestation through the plantings has not exceeded 200 feet.

The eggs are 0.1 mm. by 0.4 mm. in size, crimson in color, and have the characteristic elipsoid shape common in most Diptera. The period of oviposition coincides with the period of rapid spring shoot growth of the host trees. Eggs are deposited singly and in groups on the expending branch and leader tips, mostly behind the scales and needle bases. They are not forced into the tissue, but are simply placed on the surface of the shoot. On the fourth day of incubation the egg becomes lighter in color, and on the sixth the larva hatches. The larva immediately crawls to a natural crease or depression on the shoot surface and slowly bores into the tissue. After 4 to 6 days it is completely imbedded in the phloem, where it feeds until the following spring. The larva then migrates out on a needle to pupate. This period of migration begins in the latter part of February and continues into the first part of April.

The fully grown larva is 4 to 5 mm. long. It is flattened dorso-ventrally, has 4 rows of bilobed tubercles along the dorsal surface, and is bright orange in color. The second day after settling on a needle, the larva spins a translucent, operculate cocoon. The cocoon is composed of relatively long fibers felted together similarly to those in lepidopterous cocoons. The outside is covered with a thin coating of brittle, resin-like material giving the surface a laquered appearance. Approximately one week after the cocoon is formed the enclosed larva pupates. At the end of the second week the dark color of the imaginal head and thorax can be seen through the cocoon. The adult emerges approximately 3 weeks after the larva leaves its feeding pit.

NATURAL ENEMIES.— The principal enemies of the resin midge are 3 species of hymenopterous parasites: Platygaster diplosidis (Ashm.)[4], Euridinota

[4] Determined by C. F. W. Muesebeck, Bureau of Entomology and Plant Quarantine.

rufiventris Gir.[5], and Amblymerus sp.[5] The first is the most abundant at

[5] Determined by A. B. Gahan, Bureau of Entomology and Plant Quarantine.

the Institute of Forest Genetics. This species has one generation per year. The adults emerge about the same time in the spring as do the resin midge adults, and the females deposit their eggs in the eggs and newly hatched larvae of the host. The parasite larvae develop within the host larvae, the latter dying just before or just after spinning their cocoons. Females of P. diplosidis in captivity have been observed to oviposit without mating and to oviposit several times in a single host egg. As many as 14 adults may emerge from a single host. Whether these develop polyembrionically or from multiple oviposition is not known. The other parasite species emerged from pupae, only one individual issuing from a single cocoon. Nothing more is known of the habits except that one female E. rufiventris was observed ovipositing in a cocoon of the resin midge.

In the virgin pine forests, where the young trees constitute only a small portion of the stand, these parasites have been reported to be quite effective in controlling resin midge populations. In the plantations of the Institute, however, the stand is composed entirely of young trees. In this concentration of attractive material, the resin midge apparently is able to increase much more rapidly than the parasites. Even in the parts of the plantations that have been heavily infested for over 7 years, the incidence of parasitism is only 25 percent.

CONTROL TESTS.-- Since natural enemies have not held the resin midge population in check, some method of direct control is needed to protect these valuable plantings. Control measures, of course, can be effective only during the relatively short period in the spring when the population is exposed, and from the standpoint of cost, it is essential that a single application suffice. An application for the pupal stage, if carefully timed, can be made when practically the entire population is in that one stage. The occurrence of each of the other exposed phases, migrating larvae, adults, and eggs, is so spread out that a single application could not effectively control the population. Therefore, except for a few exploratory experiments, all tests were applied to the pupae. Two general types of materials were used: (1) substances applied to prevent escape or emerging adults by sealing the cocoons, and (2) toxic agents to kill the pupae. Materials of the first class were tested by preparing a water dispersion of each and dipping 50 pupae in the dispersion. Mortality rates were determined by noting the subsequent emergence of adults from the cocoons. The materials tested and the resulting mortality are shown in table 1. None of the treatments was sufficiently effective to warrant field use.

Insert Table 1

For testing toxic materials, needles with cocoons attached were mounted on cardboard strips with the portion bearing the cocoons projecting an inch or more beyond the edge of the strip. The strips were then placed in wooden racks and the spray mixtures applied by means of a bucket pump. Two sets of 100 pupae were sprayed with each mixture. In the first set the cocoons were given no pre-treatment. In the second set the resinous surface of each cocoon was lightly scratched with a disecting needle, care being exercised to avoid tearing the fibers of the cocoon or injuring the pupa. In both sprayed cocoons and checks mortality figures were based on subsequent emergence of adults. The mixtures tested and the resulting mortalities are given in table 2.

Insert Table 2

Table 1. Results of tests of materials applied to prevent the emergence of adults from cocoons.

Materials 1/	Mortality %
1. Bill poster's paste, 10 lbs.	12
2. Casein glue, 2 lbs.	20
3. Linseed oil, ½ gal.; emulsifier 2/, ½ pint	28
4. Miscible cellulose, 10 lbs.	28
5. Sodium silicate ($Na_2Si_4O_9$) 50 lbs.	48
6. Check	8

1/ All quantities given are for 100 gallons of spray mixture.
2/ Proprietary liquid emulsifier.

Table 2. Results of toxic sprays applied to cocoons.

Materials 1/	Mortality %	
	Cocoons unscratched	Cocoons scratche
1. Heavy tank mix oil 4 gal., nicotine sulfate (40% nicotine) 1 pt., blood albumin 4 oz.	86	100
2. Heavy tank mix oil 2 gal., other ingredients as in 1.	79	96
3. Light medium tank mix oil 4 gal., other ingredients as in 1.	81	97
4. Light medium tank mix oil 2 gal., other ingredients as in 1.	65	89
5. Light medium tank mix oil 1 gal., other ingredients as in 1.	41	79
6. Light medium oil emulsion 4 gal., nicotine sulfate (40% nicotine) 1 pt.	77	92
7. Light medium oil emulsion 2 gal., nicotine sulfate (40% nicotine) 1 pt.	45	85
8. Light medium oil emulsion 1 gal., nicotine sulfate (40% nicotine) 1 pt.	31	71
9. Light medium tank mix oil 1 gal., pyrethrum concentrate (pyrethrins 3.6%) 2 oz.	41	72
10. Light medium tank mix oil 1 gal., proprietary rotenone powder (rotenone 0.58%, ~~4 lbs.~~, other cube resins 1.74%) 4 lbs.	35	78
11. Check	6	4

1/ Quantities given are for 100 gallons of spray mixture.

These results demonstrate that successful control of the resin midge is dependent primarily on finding a suitable substance to penetrate the cocoons. The light medium oil mixtures were quite toxic when allowed to come in contact with the pupae, and were also found to be comparatively safe on ponderosa pine foliage. However, they did not readily penetrate into the cocoons unless the outer surface was broken. The heavy oil was somewhat better in penetration because of slower evaporation, but was so toxic to pine foliage as to be unsuitable for field use. Later some 25 commercial wetting and penetrating agents were tested in combination with several of the above formulas, but none increased penetration appreciably. In subsequent tests it was found that the lower alcohols will dissolve the outer surface of the cocoons and alkalis will soften it, but only in concentrations greater than 25 percent. Before any control program can be recommended, therefore, further search must be made to find a penetrant that is efficient at practical dilutions, harmless to the trees, and economical.

RESISTANT TREES.-- It was noted in the course of the life history observations that ponderosa pines in which the expending new shoots were covered with a sticky, resinous secretion were noticeably more heavily infested than were trees in which the stickiness was absent. The latter were frequently uninjured even when adjacent to heavily infested trees (Figure 2). The reason for this

Figure 2. A. Nonsusceptible ponderosa pine. Note full foliage complement and normal form. B. Susceptible ponderosa pine showing deformed leader and limbs, and dead and dying terminals caused by resin midge.

apparent difference in susceptibility is not known. It is suspected that the sticky secretion attracts the ovipositing females. The nonsticky trees apparently do not possess any factors inhibiting resin midge development, for the insects do occasionally oviposit in such trees when near susceptible trees. Furthermore, eggs placed on nonsusceptible trees either by natural deposition or in experimental transfer produce normal adults.

The presence or absence of stickiness of shoots apparently bears no relation to vigor, crown form, or other tree characteristics, so it offers no solution to the problem of protecting valuable trees in experimental plantings. However, if further study proves the absence of stickiness to be a reliable index of resistance to resin midge, it may be possible to combine this character with other desirable traits to produce planting stock which will not be subject to resin midge attack.

SUMMARY.-- This study was undertaken to develop a means of controlling a serious infestation of resin midge (Retinodiplosis sp., Cecidomyiidae) in an experimental plantation of ponderosa pine (Pinus ponderosa Laws.) and Jeffrey pine(P. jeffreyi Grev. and Bal.). The work also included observations of the life history of the insect.

The resin midge was found to have an annual life cycle. Eggs are deposited on the new shoots of the host trees in April and May. The larvae hatch in 6 days, bore into the phloem, and feed until full grown, the following spring, when they migrate out on the needles of the infested trees to pupate. Adults emerge during March, April, and May.

The principal parasites of the resin midge are Platygaster diplosidis (Ashm.) Euridinota fufiventris Gir., and Amblymerus sp. They have not been effective in checking the resin midge population in the plantations.

Control tests consisted of applications of (1) materials to prevent emergence of adults from cocoons, and (2) toxic agents to kill the pupae. None of the substances in the first class was effective. In the second class, oil sprays readily killed the pupae but they would not penetrate into the cocoons. Several commercial wetting and penetrating agents tested were not effective. Alcohols and alkalis penetrated, but only at comparatively high concentrations.

The possibility of developing ponderosa pine planting stock resistant to resin midge attack is discussed.

A B

Figure 2.-- A. Nonsusceptible ponderosa pine. Note full foliage complement and normal form. B. Susceptible ponderosa pine showing deformed leader and limbs, and dead and dying terminals caused by resin midge.